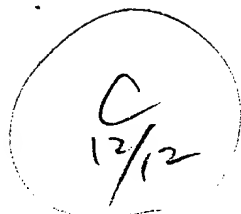


PATENT COOPERATION TREATY



PCT

NOTICE INFORMING THE APPLICANT OF THE COMMUNICATION OF THE INTERNATIONAL APPLICATION TO THE DESIGNATED OFFICES

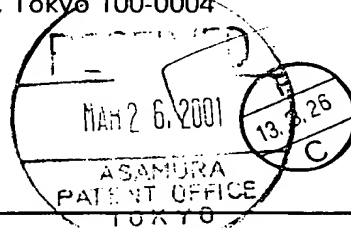
小松

(PCT Rule 47.1(c), first sentence)

From the INTERNATIONAL BUREAU

To:

ASAMURA, Kiyoshi
Room 331, New Ohtemachi Bldg.
2-1, Ohtemachi 2-chome
Chiyoda-ku, Tokyo 100-0004
JAPON



Date of mailing (day/month/year) 15 March 2001 (15.03.01)		
Applicant's or agent's file reference E5491-00		
IMPORTANT NOTICE		
International application No. PCT/JP00/05992	International filing date (day/month/year) 04 September 2000 (04.09.00)	Priority date (day/month/year) 06 September 1999 (06.09.99)
Applicant SUMITOMO BAKELITE COMPANY LIMITED et al		

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:
KR,US

In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:
CN,EP,SG

The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 49.1(a-bis)).

3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on 15 March 2001 (15.03.01) under No. WO 01/18115

REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, a demand for international preliminary examination must be filed with the competent International Preliminary Examining Authority before the expiration of 19 months from the priority date.

It is the applicant's sole responsibility to monitor the 19-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))

If the applicant wishes to proceed with the international application in the national phase, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer J. Zahra
Facsimile No. (41-22) 740.14.35	Telephone No. (41-22) 338.83.38

PCT COOPERATION TREATY

PCT

From the INTERNATIONAL BUREAU

To:

ASAMURA, Kiyoshi
Room 331, New Ohtemachi Bldg.
2-1, Ohtemachi 2-chome
Chiyoda-ku, Tokyo 100-0004
JAPON

NOTIFICATION CONCERNING
SUBMISSION OR TRANSMITTAL
OF PRIORITY DOCUMENT

(PCT Administrative Instructions, Section 411)

小松

Date of mailing (day/month/year) 03 November 2000 (03.11.00)	
Applicant's or agent's file reference E5491.00	IMPORTANT NOTIFICATION
International application No. PCT/JP00/05992	International filing date (day/month/year) 04 September 2000 (04.09.00)
International publication date (day/month/year) Not yet published	Priority date (day/month/year) 06 September 1999 (06.09.99)
Applicant SUMITOMO BAKELITE COMPANY LIMITED et al	

- The applicant is hereby notified of the date of receipt (except where the letters "NR" appear in the right-hand column) by the International Bureau of the priority document(s) relating to the earlier application(s) indicated below. Unless otherwise indicated by an asterisk appearing next to a date of receipt, or by the letters "NR", in the right-hand column, the priority document concerned was submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b).
- This updates and replaces any previously issued notification concerning submission or transmittal of priority documents.
- An asterisk(*) appearing next to a date of receipt, in the right-hand column, denotes a priority document submitted or transmitted to the International Bureau but not in compliance with Rule 17.1(a) or (b). In such a case, the attention of the applicant is directed to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.
- The letters "NR" appearing in the right-hand column denote a priority document which was not received by the International Bureau or which the applicant did not request the receiving Office to prepare and transmit to the International Bureau, as provided by Rule 17.1(a) or (b), respectively. In such a case, the attention of the applicant is directed to Rule 17.1(c) which provides that no designated Office may disregard the priority claim concerned before giving the applicant an opportunity, upon entry into the national phase, to furnish the priority document within a time limit which is reasonable under the circumstances.

<u>Priority date</u>	<u>Priority application No.</u>	<u>Country or regional Office or PCT receiving Office</u>	<u>Date of receipt of priority document</u>
06 Sept 1999 (06.09.99)	11/251600	JP	20 Octo 2000 (20.10.00)

The International Bureau of WIPO
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1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer

Magda BOUACHA

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3.7

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference E5491-00	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/JP 00/05992	International filing date (day/month/year) 04/09/2000	(Earliest) Priority Date (day/month/year) 06/09/1999
Applicant SUMITOMO BAKELITE COMPANY LIMITED et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

☒ as suggested by the applicant.

☐ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

1 _____
☐ None of the figures.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP 00/05992

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 1
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.2

Claims Nos.: 1

Present claim 1-4 relate to a composition defined (inter alia) by reference to the following parameter(s):

The use of these parameters in the present context is considered to lead to a lack of clarity within the meaning of Article 6 PCT. It is impossible to compare the parameters the applicant has chosen to employ with what is set out in the prior art. The lack of clarity is such as to render a meaningful complete search impossible. Consequently, the search has been restricted to: the compositions as set out in the examples 1-6.

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

International Application No

PT/JP 00/05992

IPC 7 C08L63/00 H01L23/29 C08L61/04 C08L65/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C08L H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

WPI Data, PAJ, EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 915 118 A (NIPPON ELECTRIC CO ;SUMITOMO BAKELITE CO (JP)) 12 May 1999 (1999-05-12) claims ---	1-4
X	DE 198 45 021 A (HITACHI CHEMICAL CO LTD) 8 April 1999 (1999-04-08) claims ---	1-4
X	PATENT ABSTRACTS OF JAPAN vol. 017, no. 640 (E-1465), 26 November 1993 (1993-11-26) & JP 05 206327 A (SUMITOMO BAKELITE CO LTD), 13 August 1993 (1993-08-13) abstract --- -/--	1-4

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

^o Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- *&* document member of the same patent family

Date of the actual completion of the international search

10 November 2000

Date of mailing of the international search report

08. 12. 2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
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Authorized officer

Deraedt, G

INTERNATIONAL SEARCH REPORT

International Application No

T/JP 00/05992

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 015, no. 007 (C-0794), 9 January 1991 (1991-01-09) & JP 02 258831 A (NIPPON STEEL CHEM CO LTD), 19 October 1990 (1990-10-19) abstract -----	1-4

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

T/JP 00/05992

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0915118	A	12-05-1999	JP 11140277 A	25-05-1999
DE 19845021	A	08-04-1999	JP 11166036 A	22-06-1999
JP 05206327	A	13-08-1993	JP 2994127 B	27-12-1999
JP 02258831	A	19-10-1990	NONE	

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



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15 March 2001 (15.03.2001)

PCT

(10) International Publication Number
WO 01/18115 A1

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H01L 23/29, C08L 61/04, 65/00

(72) Inventor; and

(75) Inventor/Applicant (for US only): OSUGA, Hironori
[JP/JP]; 3335-10-3-103, Ishimachi, Utsunomiya-shi,
Tochigi 321-0912 (JP).

(21) International Application Number: PCT/JP00/05992

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(74) Agents: ASAMURA, Kiyoshi et al.; Room 331, New
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Tokyo 100-0004 (JP).

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11/251600 6 September 1999 (06.09.1999) JP

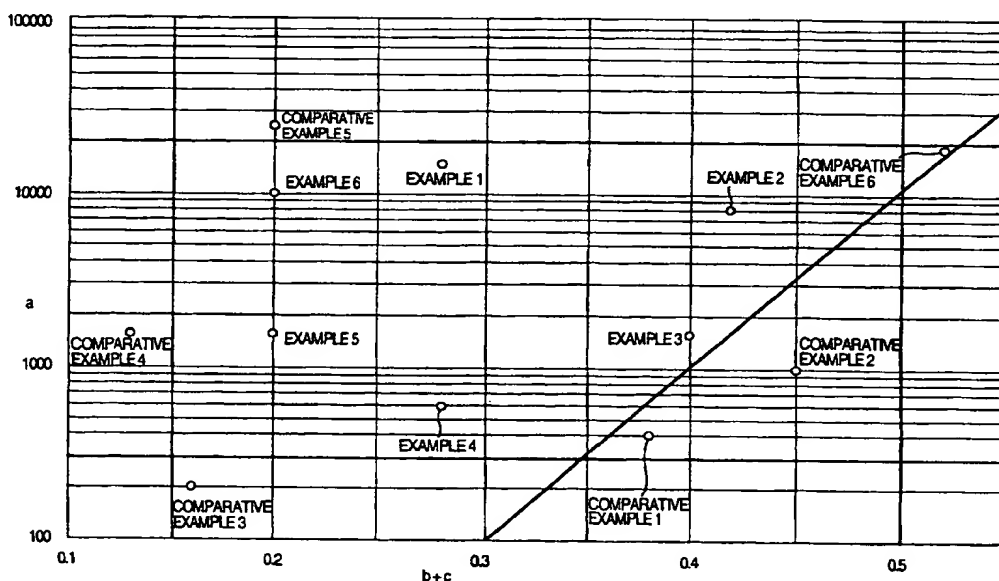
Published:

— With international search report.

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ITOMO BAKELITE COMPANY LIMITED [JP/JP];
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140-0002 (JP).

For two-letter codes and other abbreviations, refer to the "Guid-
ance Notes on Codes and Abbreviations" appearing at the begin-
ning of each regular issue of the PCT Gazette.

(54) Title: EPOXY RESIN COMPOSITION AND SEMICONDUCTOR DEVICE



(57) Abstract: The present invention provides an epoxy resin composition for encapsulating of semiconductors which is suitable for area mounting type semiconductor devices and is less in warping and excellent in soldering crack resistance. The epoxy resin composition comprises (A) an epoxy resin, (B) a phenolic resin, (C) a curing accelerator and (D) an inorganic filler as main components, where properties of a cured product formed by heating and curing the epoxy resin composition satisfy expressions, $a \geq 10^R$ ($R = 10 \times (b+c) - 1$), $300 \leq a \leq 20000$ and $0.15 \leq b+c \leq 0.50$ in which a denotes a flexural modulus (N/mm²) at molding temperature, b denotes a cure shrinkage (%) and c denotes a heat shrinkage (%) of from molding temperature to room temperature.

WO 01/18115 A1

DESCRIPTION

EPOXY RESIN COMPOSITION AND SEMICONDUCTOR DEVICE

TECHNICAL FIELD

The present invention relates to an epoxy resin composition for encapsulating of semiconductors which is suitable for the so-called area mounting type semiconductor devices formed by mounting semiconductor elements on one side of a printed circuit board or a metallic lead frame and encapsulating with a resin substantially only the side on which the semiconductor elements are mounted, and to a semiconductor device manufactured using the resin composition.

BACKGROUND ART

With the recent market trend of miniaturization, weight-saving and enhancement of performance of electronic devices, high integration of semiconductor elements has progressed year by year and surface mounting of semiconductor devices has been accelerated. Under the circumstances, area mounting type semiconductor devices have been developed afresh, and semiconductor devices of conventional structures are being switched over to the area mounting type semiconductor devices.

Representatives of the area mounting type semiconductor devices are BGA (ball grid array) and CSP (chip scale package) which pursues further miniaturization, and these have been developed for meeting the demand for

increase of pins and speed up which has reached nearly the limit in conventional surface mounting type semiconductor devices such as QFP and SOP. The structure of the area mounting type semiconductor devices is such that semiconductor elements are mounted on one side of rigid circuit boards such as BT resin/copper foil circuit board (bismaleimide·triazine resin/glass cloth substrate) or flexible circuit boards such as polyimide resin film/copper foil circuit board and only the semiconductor elements-mounted side, namely, only the one side of the boards is molded and encapsulated with an epoxy resin composition or the like. Furthermore, the structure is characterized in that solder balls are arranged in plane on the other side of the boards for bonding to a circuit board on which a semiconductor device is mounted. Moreover, as the boards on which semiconductor elements are mounted, structures using metallic substrates such as lead frames have also been developed in addition to the above organic substrates.

The structure of these area mounting type semiconductor devices has the form of one side encapsulating, that is, only the side of the board on which semiconductor elements are mounted is encapsulated with an epoxy resin composition and the side on which solder balls are formed is not encapsulated. In the case of metallic substrates such as lead frame, an encapsulating resin layer of about several ten μms is sometimes present also on the solder ball-formed side, while an encapsulating resin layer of

about several hundred μms to several millimeters is formed on the semiconductor element-mounted side, and, as a result, this is substantially one side encapsulating. Therefore, in these semiconductor devices, warping is apt to occur just after molding because of differences in thermal expansion · heat shrinkage between the organic substrate or the metal substrate and the cured product of the epoxy resin composition or because of cure shrinkage at the time of molding and curing of the epoxy resin composition. Furthermore, when these semiconductor devices are bonded onto circuit boards with solder, this is conducted through a heating step at 200°C or higher, during which warping of the semiconductor devices occurs and many solder balls are not in flat state and are apart from the circuit boards to cause deterioration in reliability of electrical bonding.

In order to decrease warping in semiconductor devices in which substantially only one side of the board is encapsulated with an epoxy resin composition, there are two important methods, one of which comprises making thermal expansion coefficient of the substrate and that of cured epoxy resin composition close to each other, and the other of which comprises reducing cure shrinkage of the cured product of epoxy resin composition.

Resins having a high glass transition temperature (hereinafter referred to as "Tg") such as BT resin and polyimide resin are widely used for organic substrates, and these have a Tg higher than about 170°C which is the molding

temperature of an epoxy resin composition. Therefore, during the cooling step of from the molding temperature to room temperature, shrinkage occurs only in the area of $\alpha 1$ of the organic substrate. Accordingly, it is considered
5 that if the cured product of epoxy resin composition also has a high T_g and the same $\alpha 1$ as that of the organic substrate and, besides, is zero in the cure shrinkage, the warping is nearly zero. Thus, there has been already proposed a method of raising the T_g by combination of a
10 polyfunctional epoxy resin and a polyfunctional phenolic resin and meeting the $\alpha 1$ by adjusting the amount of inorganic filler to be added.

Moreover, in the case of carrying out solder bonding by solder treatments such as infrared reflowing,
15 vapor phase soldering and solder dipping, water present in the semiconductor device due to absorption from the cured product of an epoxy resin composition and the organic substrate is abruptly vaporized at a high temperature to produce a stress, which causes cracking of the semicon-
20 ductor device or separation at the interface between the semiconductor element-mounted side of the organic substrate and the cured product of the epoxy resin composition. Thus, it is demanded to diminish the stress and the absorption of moisture of the epoxy resin composition and, in
25 addition, to allow the epoxy resin composition to have adhesion to the organic substrate.

Moreover, because of difference between thermal expansion coefficient of the organic substrate and that of

the cured product of epoxy resin composition, separation at the interface of organic substrate/cured product of epoxy resin composition or package cracking occurs also in a heat cycle test which is a representative reliability test.

5 In the conventional surface mounting type semiconductor devices such as QFP and SOP, a crystalline epoxy resin such as biphenyl epoxy resin and a phenolic resin having a flexible skeleton are used in combination for inhibition of cracking or separation at the interface
10 between the materials at the time of mounting with solder and the amount of an inorganic filler is increased to decrease Tg and the absorption of moisture. However, these methods cannot still solve the problem of warping in one side-encapsulated semiconductor devices.

15 DISCLOSURE OF INVENTION

The present invention provides an epoxy resin composition which causes little warping after molding or solder treatment in area mounting type semiconductor devices and is excellent in reliability of solder treatment
20 or the like because it is especially excellent in adhesion to organic substrates, and a semiconductor device manufactured using the epoxy resin composition.

The present invention relates to an epoxy resin composition for encapsulating of semiconductors which
25 comprises (A) an epoxy resin, (B) a phenolic resin, (C) a curing accelerator and (D) an inorganic filler as main components, characterized in that properties of a cured

product formed by heating and curing the epoxy resin composition satisfy expressions, $a \geq 10^R$ ($R=10 \times (b+c)-1$), $300 \leq a \leq 20000$ and $0.15 \leq b+c \leq 0.50$ in which a denotes a flexural modulus (N/mm^2) at molding temperature, b denotes a cure shrinkage (%) and c denotes a heat shrinkage (%) of from molding temperature to room temperature, and, particularly, to the above epoxy resin composition wherein the cured product has a water absorption rate of not more than 0.2% by weight after the cured product is treated for 168 hours in an environment of 85°C and 60% in relative humidity and the epoxy resin and/or the phenolic resin have/has a naphthalene skeleton, and to a semiconductor device manufactured by encapsulating semiconductor elements with said epoxy resin composition.

15 BRIEF DESCRIPTION OF DRAWING

FIG. 1 is a graph which shows relations of flexural modulus, cure shrinkage and heat shrinkage of the cured products of the epoxy resin compositions in examples and comparative examples.

20 DETAILED DESCRIPTION OF INVENTION

In order to reduce warping in semiconductor devices in which substantially only one side of the substrate is encapsulated with an epoxy resin composition, two methods have been considered to be important, namely, the one which comprises making the thermal expansion coefficient of the substrate and that of the cured product

of the epoxy resin composition close to each other and the other which comprises reducing the cure shrinkage of the epoxy resin composition. That is, it is necessary for the reduction of warping to reduce the cure shrinkage and the heat shrinkage of from molding temperature to room temperature in an epoxy resin composition comprising as main components an epoxy resin, a phenolic resin, a curing accelerator and an inorganic filler.

However, reduction of the warping is still insufficient only by carrying out reduction of the cure shrinkage and the heat shrinkage from molding temperature to room temperature, and as a result of the intensive research conducted by the inventor, it has been found that the flexural modulus of the cured product obtained by heating and curing the epoxy resin composition comprising the components (A)-(D) as main components which is measured at the molding temperature, greatly affects the warping. That is, it has been found that when the flexural modulus at molding temperature is low, warping is large, and that when the flexural modulus is high, warping is small. It has further been found that all of the flexural modulus at molding temperature, the cure shrinkage and the heat shrinkage of from the molding temperature to room temperature affect the warping in combination.

Thus, it has been found that when flexural modulus (N/mm^2) at molding temperature of the cured product is expressed by a, cure shrinkage (%) of the cured product is expressed by b and heat shrinkage (%) of from molding

temperature to room temperature is expressed by c , if these properties satisfy the expressions, $a \geq 10^R$ ($R=10 \times (b+c)-1$), $300 \leq a \leq 20000$ and $0.15 \leq b+c \leq 0.50$, the warping decreases and the soldering crack resistance is improved in the semiconductor devices in which substantially only one side of the substrate is encapsulated with the epoxy resin composition.

The molding temperature in the present invention means a temperature of a mold when the epoxy resin composition is cured by heating and is usually in the range of 160-190°C, but it is not limited to this temperature range.

The value "a" is measured in accordance with JIS K 6911.

The value "b+c" is obtained in the following manner. A cured product in the form of a disk of 100 mm in diameter and 3 mm in thickness is molded using a transfer molding machine under the conditions of a mold temperature of 175°C, an injection pressure of 70 kg/cm² and a curing time of 90 seconds, and inner diameter of the mold cavity at 175°C and outer diameter of the disk cured product at room temperature (25°C) are measured. The value "b+c" is calculated from the formula, $[(\text{inner diameter of the mold cavity at } 175^\circ\text{C}) - (\text{outer diameter of the disk cured product at } 25^\circ\text{C})] / (\text{inner diameter of the mold cavity at } 175^\circ\text{C}) \times 100$.

The cured product used for evaluation is one which has not been subjected to post-curing treatment.

In the relations of a , b and c , when a is not less than 10^R (where $R=10 \times (b+c)-1$), warping decreases and

this is preferred, and when a is less than 10^R , warping increases and this is not preferred. Furthermore, when a is less than 300, the cured product becomes soft at curing and molding to cause deterioration of releasability from the mold, namely moldability, and when a exceeds 20000, fluidity is insufficient and moldability is deteriorated. Moreover, when $b+c$ is less than 0.15, cure shrinkage at molding and curing is small and releasability from the mold is insufficient to cause deterioration of moldability, and when $b+c$ exceeds 0.50, heat shrinkage is large and due to the increase of internal stress, soldering crack resistance is lowered.

It is preferred that the cured product obtained by heating and curing the epoxy resin composition of the present invention has a moisture absorption rate of not more than 0.20% by weight after the cured product is treated for 168 hours in an environment of 85°C and 60% in relative humidity. If the moisture absorption rate exceeds 0.20% by weight, in the case of carrying out the solder bonding by solder treatment, water which is present in a semiconductor device due to the absorption from the cured product of the epoxy resin composition and the organic substrate, is abruptly vaporized at high temperatures to produce a stress, which causes cracking in the semiconductor device or separation at the interface between the semiconductor element-mounted side of the organic substrate and the cured product of the epoxy resin composition, resulting in deterioration of soldering crack resistance.

The cured product used for measurement of the moisture absorption rate is one which is removed from the mold and then post-cured at 175°C for 2 hours.

The epoxy resins used in the present invention include all of monomers, oligomers and polymers having an epoxy group, for example, triphenolmethane type epoxy resins, biphenyl type epoxy resins, bisphenol type epoxy resins, stilbene type epoxy resins, o-cresol novolak type epoxy resins, epoxy resins having a naphthalene skeleton, and dicyclopentadiene type epoxy resins. These may be used each alone or in admixture. Especially, when epoxy resins having a naphthalene skeleton are used, flexural modulus at molding temperature is high, cure shrinkage and heat shrinkage of from molding temperature to room temperature are small, and moisture absorption rate is low, and, hence, these epoxy resins are preferred.

The phenolic resins used in the present invention include all of monomers, oligomers and polymers having two or more phenolic hydroxyl groups capable of forming a crosslinked structure upon curing reaction with the above epoxy resins. Examples thereof are phenolic novolak resins, cresol novolak resins, phenolic aralkyl resins such as p-xylylene-modified phenolic resins and m-xylylene-p-xylylene-modified phenolic resins, resins having a naphthalene skeleton, terpene-modified phenolic resins, and dicyclopentadiene-modified phenolic resins. These may be used each alone or in admixture. Especially, when the resins having a naphthalene skeleton are used, flexural

modulus at molding temperature is high, cure shrinkage and heat shrinkage of from molding temperature to room temperature are small, and moisture absorption rate is low, and these resins are preferred.

5 The curing accelerators used in the present invention are those which can act as catalysts for cross-linking reaction of the epoxy resin with the phenolic resin. Examples of them are 1,8-diazabicyclo(5,4,0)-undecene-7, amine compounds such as tributylamine, organic
10 phosphorus compounds such as triphenylphosphine, tetraphenylphosphonium·tetraphenyl borate, and imidazole compounds such as 2-methylimidazole. The curing accelerators are not limited to these examples. These may be used each alone or in admixture.

15 The inorganic fillers used in the present invention have no special limitation and those generally used for encapsulating materials can be used. Examples thereof are fused silica, crystalline silica, secondary aggregation silica, alumina, titanium white, aluminum
20 hydroxide, talc, clay, and glass fibers. The fused silica is especially preferred. The fused silica may be either in crushed or spherical form, but it is more preferred to use mainly spherical silica for increasing amount thereof to be added and inhibiting increase of melt viscosity of the
25 epoxy resin composition. In order to further increase the amount of spherical silica to be added, it is desirable to carry out adjustment so that particle size distribution of spherical silica becomes broader.

With regard to the proportions of components (A) to (D) in the epoxy resin composition of the present invention, the proportion of a phenolic resin (B) is 20-300 parts by weight, the proportion of a curing accelerator (C) is 0.1-30 parts by weight, and the proportion of an inorganic filler (D) is 200-2000 parts by weight on the basis of 100 parts by weight of an epoxy resin (A). When the proportion of a phenolic resin (B) is less than 20 parts by weight, curing is insufficient, and when said proportion exceeds 300 parts by weight, the problem that uncured material remains is caused. When the proportion of a curing accelerator (C) is less than 0.1 part by weight, it takes a long time until curing is completed, and when said proportion exceeds 30 parts by weight, curing proceeds rapidly and satisfactory cured product cannot be obtained. When the proportion of an inorganic filler (D) is less than 200 parts by weight, soldering crack resistance is inferior, and when said proportion exceeds 2000 parts by weight, fluidity of the resin composition becomes bad to give insufficient moldability.

The epoxy resin composition of the present invention may optionally contain, in addition to the components (A)-(D), various additives, for example, flame retardants such as brominated epoxy resin, antimony oxide and phosphorus compounds, inorganic ion exchangers, coupling agents, coloring agents such as carbon black, releasing agents such as natural wax, synthetic wax, higher fatty acids and metallic salts thereof and paraffin, low

stress components such as silicone and rubber, and antioxidants.

The epoxy resin composition of the present invention is obtained by mixing the components (A)-(D) and
5 other additives by a mixer, then heating and kneading the mixture by a kneader such as a heating kneader, a hot roll and an extruder, and cooling and grinding the kneaded product.

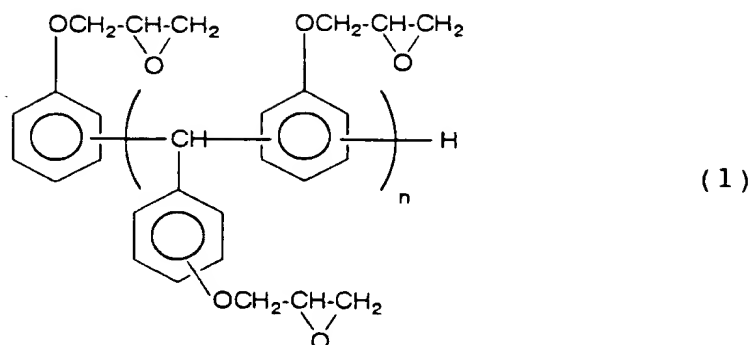
For producing semiconductor devices by encapsu-
10 lating electronic parts such as semiconductor elements with the epoxy resin composition of the present invention, the composition can be cured and molded by conventional molding methods such as transfer molding, compression molding and injection molding.

15 BEST MODE FOR CARRYING OUT THE INVENTION

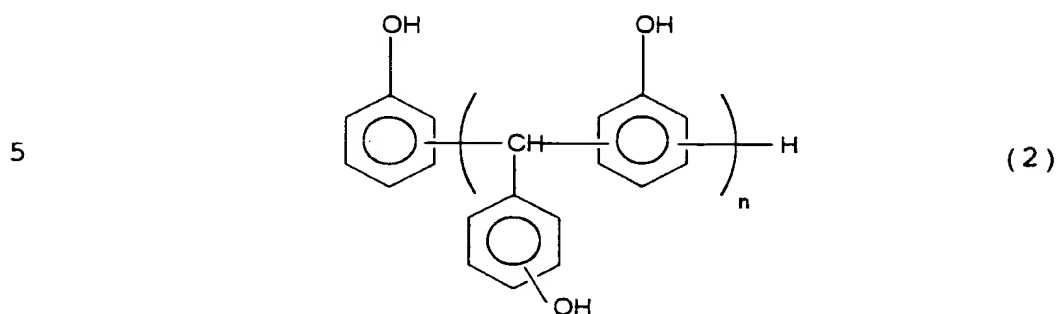
The present invention will be explained specifically by the following examples. The proportions of various components are expressed by part by weight.

Example 1

20 10.2 Parts by weight of an epoxy resin represented by the following formula (1) (Epikote 1032H manufactured by Yuka Shell Epoxy Co., Ltd.; softening point: 60°C, epoxy equivalent: 170):



5.8 parts by weight of a phenolic resin represented by the following formula (2) (MEH7500 manufactured by Meiwa Kasei Co., Ltd.; softening point: 105°C, hydroxyl equivalent: 97):



0.15 part by weight of triphenylphosphine, 83.25 parts by weight of spherical fused silica (average particle diameter: 15 μ m), 0.3 part by weight of carnauba wax and 0.3 part by weight of carbon black were mixed by a mixer, then the mixture was kneaded using a twin roll having surface temperatures of 90°C and 45°C for 5 minutes, and the kneaded product was cooled and then ground to obtain an epoxy resin composition. The resulting epoxy resin composition was evaluated by the following methods. The results are shown in Table 1.

Evaluation methods:

Spiral flow: Measurement was conducted using a mold for measurement of spiral flow in accordance with EMMI-1-66 under the conditions of a mold temperature of 175°C, an injection pressure of 70 kg/cm² and a curing time of 2 minutes.

Curability: Measurement was conducted using Shore "D" durometer under the conditions of a mold temperature of 175°C, an injection pressure of 70 kg/cm² and a curing time of 90 seconds.

Flexural modulus "a" at molding temperature: Measurement was conducted in accordance with JIS K 6911 as mentioned above. A cured product was molded using a transfer molding machine under the conditions of a mold temperature of 175°C, an injection pressure of 70 kg/cm² and a curing time of 90 seconds, and the flexural modulus was measured at 175°C. The unit was N/mm².

"b+c": As mentioned above, a cured product in the form of a disk of 100 mm in diameter and 3 mm in thickness was molded using a transfer molding machine under the conditions of a mold temperature of 175°C, an injection pressure of 70 kg/cm² and a curing time of 90 seconds, and inner diameter of the mold cavity at 175°C and outer diameter of the disk cured product at room temperature (25°C) were measured. The value "b+c" was calculated from the formula, $\left[\frac{(\text{inner diameter of the mold cavity at } 175^{\circ}\text{C}) - (\text{outer diameter of the disk cured product at } 25^{\circ}\text{C})}{(\text{inner diameter of the mold cavity at } 175^{\circ}\text{C})} \right] \times 100$. The unit

was %.

Moisture absorption rate: A disk of 50 mm in diameter and 3 mm in thickness was molded using a transfer molding machine under the conditions of a mold temperature of 175°C, an injection pressure of 70 kg/cm² and a curing time of 90 seconds, and post-cured at 175°C for 2 hours. The cured product was further treated for 168 hours in an environment of 85°C and 60% in relative humidity, and change of weight was measured. The unit was % by weight.

10 Warping amount of package: A 225pBGA (BT resin substrate of 0.36 mm in thickness; chip size: 12 mm × 12 mm × 0.35 mm thick; package size: 24 mm × 24 mm; thickness of encapsulating resin: 1.17 mm) was molded using a transfer molding machine under the conditions of a mold temperature
15 of 175°C, an injection pressure of 70 kg/cm² and a curing time of 90 seconds, and post-cured at 175°C for 2 hours. The cured product was cooled to room temperature, and, thereafter, displacement in the height direction was measured using a surface roughness meter in diagonal
20 direction from the gate of the package. The largest value of displacement was taken as amount of warping. The unit was μm.

Soldering crack resistance: The above 225pBGA was molded, and post-cured at 175°C for 2 hours to obtain ten
25 samples. These were treated for 168 hours in an environment of 60°C and 60% in relative humidity or in an environment of 85°C and 60% in relative humidity, and, then, treated by IR reflowing (240°C) for 10 seconds. The samples

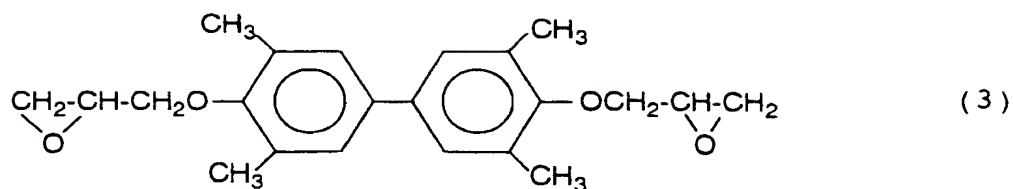
were observed by an ultrasonic defectoscope to examine the presence of internal cracks and various interfacial separations. When the number of defective packages was n , this was expressed by $n/10$.

- 5 Releasability: Releasability from the mold at the time of molding of the above 225pBGA was examined. The product which was not smoothly removable from the mold was judged to be bad.

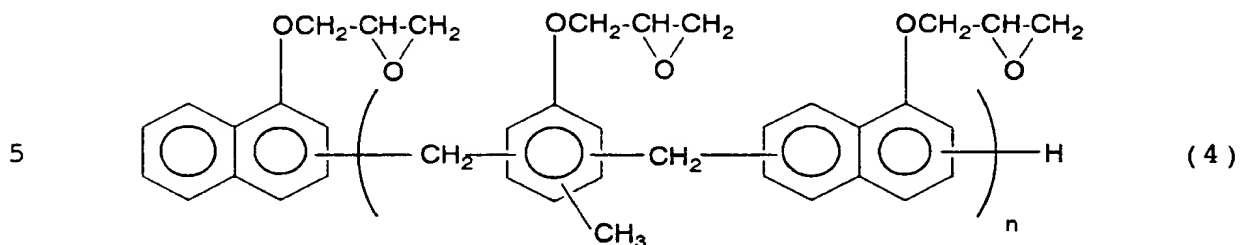
Examples 2-6 and Comparative Examples 1-6

- 10 Components were mixed in accordance with Tables 1 and 2, and epoxy resin compositions were prepared in the same manner as in Example 1 and these were evaluated in the same manner as in Example 1. The results are shown in
15 Tables 1 and 2. Structures and properties of the epoxy resins and phenolic resins used in the examples and the comparative examples are shown below.

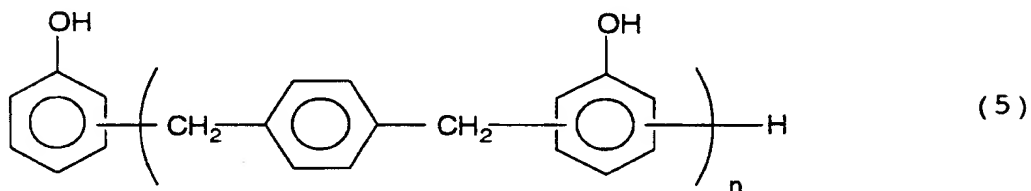
- Epoxy resin comprising a main component represented by the following formula (3) (YX-4000H manufactured by Yuka Shell Epoxy Co., Ltd.; melting point: 105°C,
20 epoxy equivalent: 195):



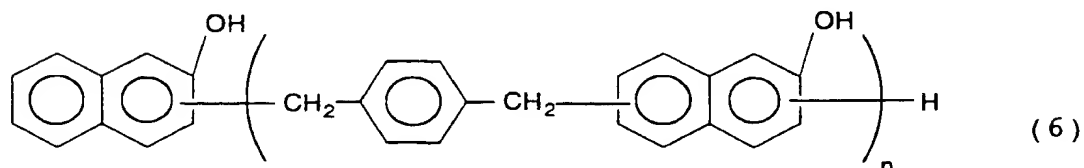
Epoxy resin represented by the following formula
 (4) (NC7000 manufactured by Nippon Kayaku Co., Ltd.;
 softening point: 90°C, epoxy equivalent: 225):



Phenolic resin represented by the following
 formula (5) (softening point: 83°C, hydroxyl equivalent:
 175):



Phenolic resin represented by the following
 formula (6) (softening point: 80°C, hydroxyl equivalent:
 200):



Phenolic novolak resin (softening point: 80°C,
hydroxyl equivalent: 105).

Table 1

	Example					
	1	2	3	4	5	6
Epoxy resin of formula (1)	10.2	10.2				7.6
Epoxy resin of formula (3)			4.2	5.9		
Epoxy resin of formula (4)					6.4	
Phenolic resin of formula (2)	5.8	5.8				4.4
Phenolic resin of formula (5)			3.8			
Phenolic resin of formula (6)				6.1	5.6	
Spherical fused silica	83.25	83.30	91.25	87.20	87.30	87.30
Triphenylphosphine	0.15	0.10	0.15	0.20	0.10	0.10
Carbon black	0.3	0.3	0.3	0.3	0.3	0.3
Carnauba wax	0.3	0.3	0.3	0.3	0.3	0.3
Spiral flow (cm)	100	100	80	70	80	70
Curability	95	95	90	95	95	95
Flexural modulus a (N/mm ²)	14000	8000	1500	600	1500	10000
b + c (%)	0.28	0.42	0.40	0.28	0.20	0.20
Moisture absorption rate (wt%)	0.26	0.27	0.10	0.10	0.09	0.22
Releasability	Good	Good	Good	Good	Good	Good
Warping amount of package (μ m)	50	80	80	30	20	30
Soldering crack resistance (60°C)	0/10	0/10	0/10	0/10	0/10	0/10
Soldering crack resistance (85°C)	10/10	10/10	0/10	0/10	0/10	8/10

Table 2

	Comparative Example					
	1	2	3	4	5	6
Epoxy resin of formula (1)				4.9	7.6	12.7
Epoxy resin of formula (3)	10.7	6.3	5.2			
Phenolic resin of formula (2)	5.3				4.4	7.3
Phenolic resin of formula (5)		5.7				
Phenolic novolak resin			2.8	3.1		
Spherical fused silica	83.25	87.20	91.35	91.35	87.15	79.10
Triphenylphosphine	0.15	0.20	0.05	0.05	0.25	0.30
Carbon black	0.3	0.3	0.3	0.3	0.3	0.3
Carnauba wax	0.3	0.3	0.3	0.3	0.3	0.3
Spiral flow (cm)	100	80	70	70	20	140
Curability	95	85	50	85	95	100
Flexural modulus a (N/mm ²)	400	1000	200	1600	24000	17000
b + c (%)	0.38	0.45	0.16	0.13	0.20	0.52
Moisture absorption rate (wt%)	0.16	0.11	0.08	0.15	0.26	0.33
Releasability	Good	Good	Bad	Bad	Unfilled	Good
Warping amount of package (μ m)	110	120	40	30	Unfilled	130
Soldering crack resistance (60°C)	0/10	0/10	0/10	0/10	Unfilled	10/10
Soldering crack resistance (85°C)	2/10	0/10	0/10	5/10	Unfilled	10/10

As clear from the above Table 1, the area mounting type semiconductor devices obtained using the epoxy resin composition of the present invention are less in warping after molding or soldering treatment and excellent in soldering crack resistance.

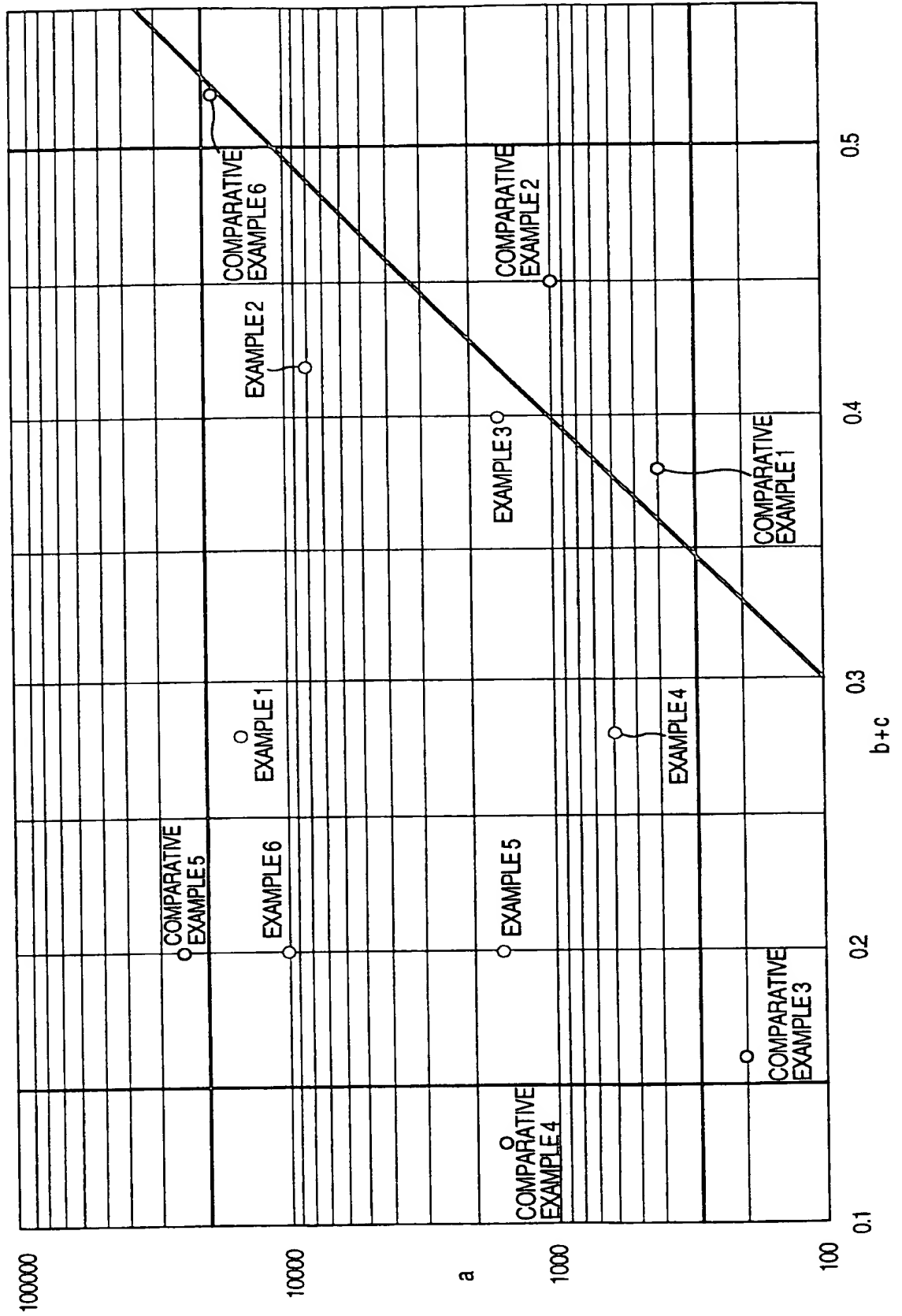
INDUSTRIAL APPLICABILITY

The epoxy resin composition of the present invention can be applied to encapsulating of various semiconductor devices and is especially suitable for BGA (ball grid array) and CSP (chip scale package). The semiconductor devices obtained by encapsulating with the resin composition of the present invention can be used for computers, liquid crystal display devices, portable telephones and the like.

CLAIMS

1. An epoxy resin composition for encapsulating of semiconductors which comprises (A) an epoxy resin, (B) a phenolic resin, (C) a curing accelerator and (D) an inorganic filler as main components, characterized in that properties of a cured product formed by heating and curing the epoxy resin composition satisfy expressions, $a \geq 10^R$ ($R=10 \times (b+c)-1$), $300 \leq a \leq 20000$ and $0.15 \leq b+c \leq 0.50$ in which a denotes a flexural modulus (N/mm^2) at molding temperature, b denotes a cure shrinkage (%) and c denotes a heat shrinkage (%) of from molding temperature to room temperature.
2. An epoxy resin composition for encapsulating of semiconductors according to claim 1, wherein the cured product has a moisture absorption rate of not more than 0.20% by weight after treated for 168 hours in an environment of 85°C and 60% in relative humidity.
3. An epoxy resin composition for encapsulating of semiconductors according to claim 1 or 2, wherein the epoxy resin and/or the phenolic resin have/has a naphthalene skeleton.
4. A semiconductor device obtained by encapsulating with the epoxy resin composition according to claim 1, 2 or 3.

FIG. 1



INTERNATIONAL SEARCH REPORT

International Application No

PCT/JP 00/05992

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C08L63/00 H01L23/29 C08L61/04 C08L65/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C08L H01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

WPI Data, PAJ, EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 915 118 A (NIPPON ELECTRIC CO ;SUMITOMO BAKELITE CO (JP)) 12 May 1999 (1999-05-12) claims	1-4
X	DE 198 45 021 A (HITACHI CHEMICAL CO LTD) 8 April 1999 (1999-04-08) claims	1-4
X	PATENT ABSTRACTS OF JAPAN vol. 017, no. 640 (E-1465), 26 November 1993 (1993-11-26) & JP 05 206327 A (SUMITOMO BAKELITE CO LTD), 13 August 1993 (1993-08-13) abstract	1-4
	-/-	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

10 November 2000

Date of mailing of the international search report

08.12.2000

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INTERNATIONAL SEARCH REPORT

In International Application No

PCT/JP 00/05992

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	<p>PATENT ABSTRACTS OF JAPAN vol. 015, no. 007 (C-0794), 9 January 1991 (1991-01-09) & JP 02 258831 A (NIPPON STEEL CHEM CO LTD), 19 October 1990 (1990-10-19) abstract</p> <p>-----</p>	1-4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP 00/05992

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 1
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
see FURTHER INFORMATION sheet PCT/ISA/210

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International Application No. PCT/JP 00 05992

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.2

Claims Nos.: 1

Present claim 1-4 relate to a composition defined (inter alia) by reference to the following parameter(s):

The use of these parameters in the present context is considered to lead to a lack of clarity within the meaning of Article 6 PCT. It is impossible to compare the parameters the applicant has chosen to employ with what is set out in the prior art. The lack of clarity is such as to render a meaningful complete search impossible. Consequently, the search has been restricted to: the compositions as set out in the examples 1-6.

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

INTERNATIONAL SEARCH REPORT

Information on patent family members

In International Application No

PCT/JP 00/05992

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0915118	A	12-05-1999	JP 11140277 A	25-05-1999
DE 19845021	A	08-04-1999	JP 11166036 A	22-06-1999
JP 05206327	A	13-08-1993	JP 2994127 B	27-12-1999
JP 02258831	A	19-10-1990	NONE	